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# Photographic photometries and astrophysical parameters of the open clusters NGC1750 and NGC1758 \*

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**Abstract.** *BV* photographic photometries of 789 stars in the region of the open clusters NGC1750 and NGC1758 are derived from a set of 8 photometric plates. According to the astronomical data including proper motions, positions and membership probabilities of individual stars, several astrophysical parameters for these two clusters are determined, such as HR diagrams, ages, distances, luminosity functions, masses and kinematics, etc. It is found that the distances are  $(525 \pm 48 \text{ pc})$  and  $(794 \pm 73 \text{ pc})$  with ages of  $1.5 \times 10^8 \text{ yr}$  and  $6.3 \times 10^8 \text{ yr}$  for NGC1750 and NGC1758 respectively. Both clusters show no significant mass segregation effects because of their relatively young ages. The analysis of the proper motions imply that their velocity distributions are isotropy.

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## 1. Introduction

Open clusters, as systems of stars having a common origin, provide a very powerful tool on studying stellar evolution history. The homogeneity of photometric characteristics of stars in a cluster and their dynamics indicate that the cluster stars should have formed from one and the same primordial cloud within a relatively short time scale. Therefore, almost all member stars in a cluster should have roughly same age and chemical composition. Furthermore, open clusters can be used to understand both the formation and kinematics of the Galactic disk due to their wide age and mass distributions. For these reasons, open clusters constitute one of the most important research fields in observational and theoretical astronomy. Ages, distances, masses, luminosity functions and mass functions of open clusters are their basic researches.

The region of the open cluster NGC1750 has been paid more and more attention mainly because it is a complex area including two open clusters (NGC1750 and NGC1758) and the Taurus dark clouds, which located in the anticenter direction of the Galaxy. Cuffey(1937) was the first one to study this area systematically, obtaining extensive photographic photometry of stars in blue and red photometric bands to a limiting magnitude about  $R \sim 14$  mag. However he did not clearly point out the existence of two open clusters in this region. He considered the whole area as NGC1746 with distance about 590pc and  $B-R \approx 0.30$ mag.

More recently, Galadí-Enríquez et al. (1998a, hereafter GJTR; 1998b; 1998c) did a series of studies of the open clusters NGC1750 and NGC1758, in which *UBVRI* CCD photometry of 3224 stars within the  $45' \times 45'$  area was presented. At the same time, they combined different plates from several observatories to obtain proper motions for 45036 stars, and *BVR* photographic photometry of 39762 stars within  $2^\circ.3 \times 2^\circ.3$  in this area was completed down to  $V \sim 18.5$  mag. Several physical parameters for NGC1750 and NGC1758 were discussed, including their positions, sizes, density profiles, extinctions, distances, ages, luminosity functions and masses, etc. Tian et al. (1998, hereafter TZSS) obtained high-precision proper

motions and membership probabilities for 540 stars within  $1^\circ 5' \times 1^\circ 5'$  in this area using 20 plates taken over a period of up to 68 years from Zö-Sé 40cm Astrograph in Shanghai Astronomical Observatory, Chinese Academy of Sciences. In that work the two open clusters, NGC1750 and NGC1758, are successfully separated from each other. The core radii of the clusters have been estimated to be  $17'.20$  and  $2'.25$  respectively.

In this paper, we will present the results of photographic photometry of 789 stars to a limit of  $V \sim 16$  mag within a  $35' \times 35'$  area round the center of NGC1750. Combining the results of proper motions and membership probabilities for individual stars, we will more deeply study some astrophysical parameters of the two open clusters, including their H-R diagrams, distances, ages, masses, mass functions and kinematics. The program is as follows. In sec. 2, we will introduce the data reduction and compare with previous work. Detailed discussion on the basic astrophysical researches are presented in Sec.3. Summary is arranged in the final section.

## 2. Photographic Photometry

### 2.1. Observations, measurements and data reduction

The photographic photometries in the  $B$  and  $V$  bands were obtained from plates taken during 1992-1993 with the 1.56 meter reflecting telescope of Shanghai Astronomical Observatory, Chinese Academy of Sciences. The plates cover an area of about  $35' \times 35'$ , centered at  $\alpha_{2000}=5^h 3^m 30^s$ ,  $\delta_{2000}=23^\circ 44'$ , which includes the clusters of NGC1750 and NGC1758. The standard plate/filter combinations are IlaO+GG385 for the  $B$  band and 156-01+GG495 for the  $V$  band. The size of individual plates is  $160\text{mm} \times 160\text{mm}$  with a scale of  $13''.25/\text{mm}$ , and the exposure time of individual plates is 30 minutes except for two plates, which have exposures of only 16 minutes. All plate materials are listed in Table 1, in which the first column denotes the plate number; the second column gives the epoch; filter and emulsion are shown respectively in Column 3 and 4; Column 5 is the exposure time; and the last two columns are the number of standard stars adopted and the reduced residual for each plate respectively (see below).

The density measurements of the whole areas of individual plates were done on the Photometric Data Systems (PDS) model 1010 automatic measuring machine

**Table 1. The plate materials for NGC1750 and NGC1758**

plate	epoch	filter	emulsion	exp.time (min)	N	$\sigma$
cl93008	1993.1.18	GG495	156 – 01	30	34	0.027
cl93011	1993.11.19	GG495	156 – 01	30	31	0.029
cl93017	1993.1.14	GG495	156 – 01	16	29	0.031
cl93018	1993.11.14	GG495	156 – 01	16	23	0.037
cl93012	1993.1.25	GG385	IaO	30	23	0.043
cl93005	1993.1.17	GG385	IaO	30	29	0.031
cl92001	1992.11.29	GG385	IaO	30	34	0.027
cl92002	1992.11.29	GG385	IaO	30	31	0.046

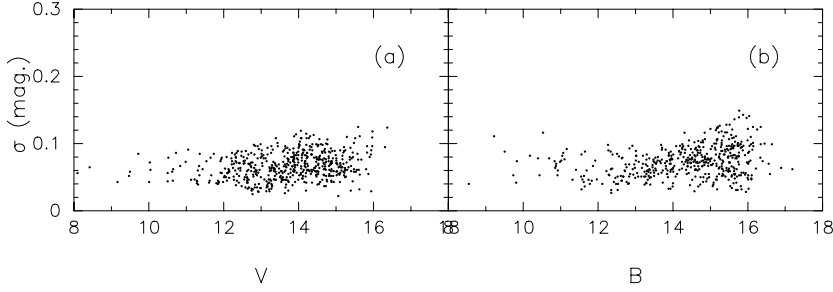
at the Dominion Astrophysical Observatory (DAO) of Canada. The reductions of  $B, V$  magnitudes were carried out according to the method presented by Stetson (1979). Because the range of candidate stars on each plate covers more than 7 magnitudes, the images of bright stars are generally saturated when the densities of faint stars can be measured. The fits of Gaussian point-spread-functions (PSF) to the unsaturated stars are good. However, the difference between the real PSF and Gaussian distribution of saturated stars are obvious, especially for stars in the cluster center region. Fortunately, Stetson (1979) has already concerned these two kinds of situations. The photographic magnitude index  $\mu$  can be defined by the following equation

$$\mu = constant - 5 \text{Log}(D), \quad (1)$$

where  $D$  is a measure of the total density of each star on a plate.

The magnitude indices for each band are averaged together among all plates, and the individual plates are transformed to this average plate by the least-squares method. At the same time, these fittings permit the standard error of a magnitude index on a typical plate to be estimated from the transformation residuals.

The Johnson-system  $BV$  photometric magnitudes are obtained by means of 141 secondary standard stars in this region with  $BV$  CCD photometry presented by GJTR before their paper was published. The magnitudes of these stars are all



**Fig. 1.** The accuracies of stars measured on at least 3 plates as a function of apparent magnitude: (a)  $V$  band (b)  $B$  band

brighter than magnitude 14 in both the  $B$  and  $V$  bands. In addition, we choose about 40 standard stars fainter than magnitude 14 from Table 5 of GJTR, which have a homologous distribution on our plates. Our photographic magnitude transformation equations are cubic polynomials in  $B$  and  $V$ , with a linear color term in each band. Generally, the candidate stars of the photometric standards should obey two principles (see Shu et al. 1998 for details): (1) the photometric standards should be distributed as homogeneously as possible along the magnitude interval covered on the plates; (2) they should be well isolated. The number of the standard stars used in the transformation of each plate and the residual rms are listed in Column 6 and 7 of Table 1 respectively.

The total number of stars we measured in the present study is 789. Their  $B$  and  $V$  magnitudes extend down to about 16.5 mag with accuracies estimated by both averaging the individual measurements of each star and considering the weighted internal error of the profile fitting. Because the centers of the available photographic plates are not exactly the same, some stars with large fitting errors must be discarded. At the same time, it is worthy noting that  $BV$  magnitudes of some stars are taken from only one or two plates. As a result, all 789 stars have  $V$  magnitudes, with 540 stars among them measured on three or four plates, and only 653 stars have  $B$  magnitudes, among which 481 were measured on three or four plates. The final accuracy for the stars which are measurable on at least three plates is given as a function of apparent visual magnitude in Table 2 and illustrated in Figure 1. One can see that average accuracies are almost the same for different magnitudes except for the faint end, which show larger scatters.

The accuracies of the derived magnitudes depend on the film of the plates and its homogeneity, the magnitude range of the standard stars used in the reductions,

**Table 2. Number of stars observed (N) and averaged accuracy ( $\sigma$ ) at different magnitude intervals**

magnitude range(mag)	V		B	
	N	$\sigma$ (mag)	N	$\sigma$ (mag)
$\leq 10.$	6	0.061	6	0.073
10.0 – 11.0	12	0.064	12	0.074
11.0 – 12.0	29	0.059	22	0.063
12.0 – 13.0	107	0.063	44	0.062
13.0 – 14.0	143	0.067	88	0.067
14.0 – 15.0	164	0.075	120	0.077
15.0 – 16.0	77	0.074	158	0.085
16.0 – 17.0	2	0.110	31	0.088
total	540	0.070	481	0.077

and the uncertainty resulting from transforming to the standard system. In general, it is difficult to obtain an accuracy of photographic photometry better than 0.1 mag. In the present study, it must be pointed out that the average accuracies of V magnitudes of the 540 stars and of B magnitudes of the 481 stars, which are measured at least three as mentioned above, are  $\pm 0.070$  mag and  $\pm 0.077$  mag, respectively. The reasons are: (1) most of our standard stars have B and V CCD data with very high accuracies; (2) the standard stars we adopted have a homogeneous distribution in both position and magnitude; (3) The method we chosen is reasonable.

The final reduced photometric results for individual stars in the region of NGC1750 and NGC1758 are given in Table 3, which is available only in electronic form. We present a small part of Table 3 here as an example. Column 1 in Table 3 is the ordinal star number in order of increasing right ascension; Column 2 and column 3 present the equatorial coordinates of J2000; Column 4-6 and 7-9 are  $V$  and  $B$  magnitudes with corresponding standard error and the number of measured plates respectively. The 10th column lists the identification of TZSS. The next two columns, 11 and 12, show the membership probabilities of individ-

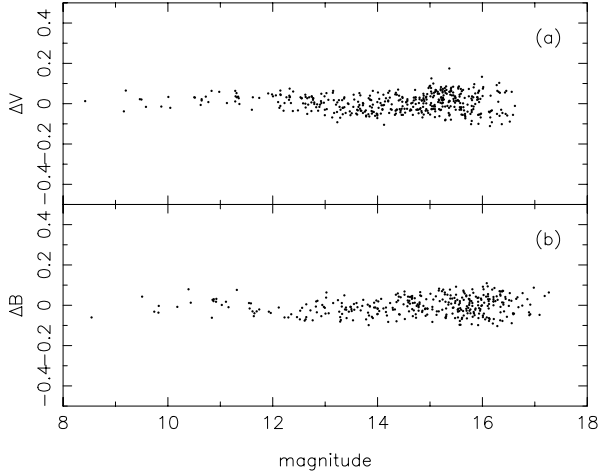
**Table 3. The photometry Catalogue of the open clusters NGC1750 and NGC1758, which is available in the electric form (see text)**

No.	R.A.(1950) ( <sup>h</sup> <sup>m</sup> <sup>s</sup> )	DEC(1950) ( <sup>°</sup> <sup>'</sup> <sup>''</sup> )	V	$\sigma_V$	N <sub>V</sub>	B	$\sigma_B$	N <sub>B</sub>	ID (TZSS)	P1	P2	ID (GJTR)
1	2	3	4	5	6	7	8	9	10	11	12	13
.....	.....											
456	5 4 30.89	+23 47 35.4	11.353	0.053	3	0.392	0.046	4	238	0.14	0.84	2659
457	5 4 30.96	+23 45 45.4	16.004	0.020	2							2660
458	5 4 31.02	+23 50 34.1	14.410	0.020	2	0.834	0.065	4				2664
459	5 4 31.14	+23 40 33.0	12.061	0.050	4	0.405	0.049	4	330	0.96	0.00	2665
460	5 4 31.36	+23 43 3.9	14.643	0.020	2	0.884	0.072	4				2671
461	5 4 31.37	+23 49 32.6	15.256	0.020	2	1.038		2				2674
462	5 4 31.54	+23 47 31.8	12.626	0.050	4	0.908	0.063	4	239	0.00	0.00	2676
463	5 4 31.65	+23 48 48.1	15.829	0.020	2							2680
464	5 4 31.78	+24 1 24.5	12.444	0.060	4	1.037	0.074	4				
465	5 4 31.88	+23 45 36.2	12.929	0.028	4	0.523	0.065	4	261	0.29	0.70	2688
466	5 4 31.95	+23 33 18.9	15.385	0.094	3	0.726		2				2687
467	5 4 32.21	+24 1 21.3	13.260	0.086	4	0.654	0.070	4	104	0.06	0.00	
468	5 4 32.39	+23 43 25.3	15.179	0.020	0	1.022		2				2702
469	5 4 32.65	+23 50 23.0	14.845	0.020	2	0.847	0.111	3				2707
470	5 4 32.79	+23 36 51.3	13.227	0.029	4	0.710	0.033	4	372	0.67	0.00	2708
471	5 4 32.94	+23 50 8.5	13.864	0.086	4	0.789	0.073	4	198	0.07	0.92	
472	5 4 32.98	+23 35 59.4	10.835	0.067	3	0.271	0.077	4	386	0.96	0.00	2711
473	5 4 33.02	+23 50 9.5	13.857	0.059	4	0.753	0.061	4				2716
474	5 4 33.11	+23 38 27.1	15.071	0.065	3	0.840		2				2717
475	5 4 33.20	+23 43 52.9	15.318	0.020	2							2721
.....	.....											

ual stars in NGC1750 and NGC1758 taken from TZSS. The cross-identification with GJTR (their ordinal star number) is given in the last column.

## 2.2. Comparisons

Here we estimate the external error of our  $V$  and  $B$  magnitudes through comparison with GJTR's CCD photometry. There are 448 and 347 common stars with  $V$  and  $B$  magnitudes respectively between our Table 3 and GJTR's photometry catalogue. Their differences  $\Delta V$  and  $\Delta B$  in  $V$  and  $B$  bands as a function of magnitude for these stars are listed in Table 4 and shown in Figure 2. The mean differences in  $V$  and  $B$  magnitude are both  $\pm 0.045$  mag. It can be found clearly



**Fig. 2.** The magnitude differences between our and GJTR's results: (a)  $V$  band (b)  $B$  band

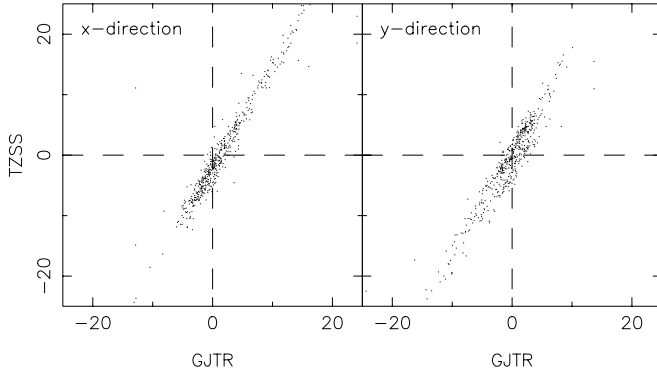
that this mean difference is small than the internal accuracy of stars available on at least three plates. It must be emphasized that this difference is not the external accuracy. It is because that our result is reduced from that of GJTR which has a very good accuracy. Furthermore, this also implies that the reduced method we adopted is reasonable. In fact, the mean difference of the 540 and 481 stars available on at least three plates in  $B$  and  $V$  band respectively are larger than above we estimated in Table 2. It is consistent with the normal principle that the external accuracy must be worse than the internal accuracy. Thus the difference seems better

In Figure 3 we compare the proper motions in the  $x$  and  $y$  directions for 517 stars common between our and GJTR's proper motion catalogs. The two astrometric results are obtained from different plate sets, reference stars of proper motions and reduce method. It is found clearly that a fairly good linear relation exists in both components of the proper motions, but the slope is not unity. Although the proper motion in the present work is slightly larger than that of GJTR in both directions, which is due to the different reference frames adopted, it can be concluded that the two sets of results are consistent with each other, and there will be no significant difference in the results of membership determination because of the linear transformation.



**Table 4.** The magnitude differences between this work and GJTR's results

magnitude	V		B	
range(mag)	N	$\Delta V(\text{mag})$	N	$\Delta B(\text{mag})$
$\leq 10.0$	7	0.032	5	0.039
$10.0 - 11.0$	11	0.035	9	0.039
$11.0 - 12.0$	14	0.037	14	0.033
$12.0 - 13.0$	53	0.033	22	0.045
$13.0 - 14.0$	73	0.040	45	0.041
$14.0 - 15.0$	100	0.037	68	0.037
$15.0 - 16.0$	160	0.053	108	0.046
$\geq 16.0$	30	0.064	76	0.055
total	448	0.045	347	0.045

**Fig. 3.** The comparisons of the proper motions (in mas/yr) between this work and GJTR.

### 3. Physical Parameters of NGC1750 and NGC1758

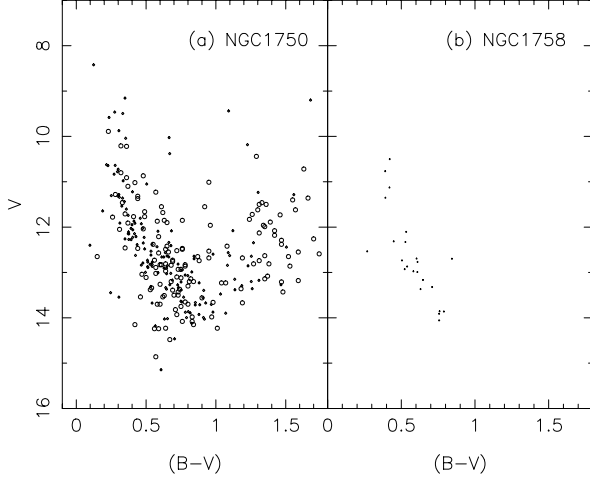
In order to investigate the basic astrophysical parameters of these two clusters, we must construct samples of members with positions, kinematics, membership probabilities and photometries available for individual stars. In the present work, there are 504 stars with both  $B$ ,  $V$  photometry and proper motion data, for which positions, proper motions and membership probabilities can be obtained from our previous work (TZSS).  $B$  and  $V$  magnitudes for 238 stars among them are taken from Table 3 and those for the remaining 266 are taken from the photometries done by GJTR. The sums of the membership probabilities for these 504 stars

belong to NGC1750 and NGC1758 are 314 and 28 respectively. Meanwhile, the numbers of stars with membership probabilities higher than 0.7 for NGC1750 and NGC1758 are 311 and 23. We reasonably choose these 311 and 23 stars as our selected samples to analyze the CM diagram of the two clusters, in order to obtain the distances, ages and the kinematics of the individual clusters. On the other hand, all 504 stars are used to study the luminosity functions and mass functions (see below).

### 3.1. Color-magnitude diagrams, distances and ages

The CM diagram offers a powerful diagnostic of the evolutionary state of an open cluster. Because the locations of open clusters tend to be close to the plane of the Galaxy, their CM diagrams are liable to be heavily contaminated by unrelated field stars, and some caution must be taken into account to minimize this contamination by selecting stars on the basis of their kinematics, or by selecting only those stars with colors that are consistent with objects that have been reddened by the dust between us and the cluster. Figure 4 shows the observed CM diagrams of NGC1750 and NGC1758, respectively, based on the sample described above. The dots denote stars with  $B$  and  $V$  taken from the present work and the open circles denote the stars with photometries from GJTR. It can be seen that both observational color-magnitude diagrams show fairly clear main sequences. Toward the bottom of the diagram, the main sequence becomes boarder for NGC1750, with a width too large to be attributed to observational errors, which reflects the containination of field stars

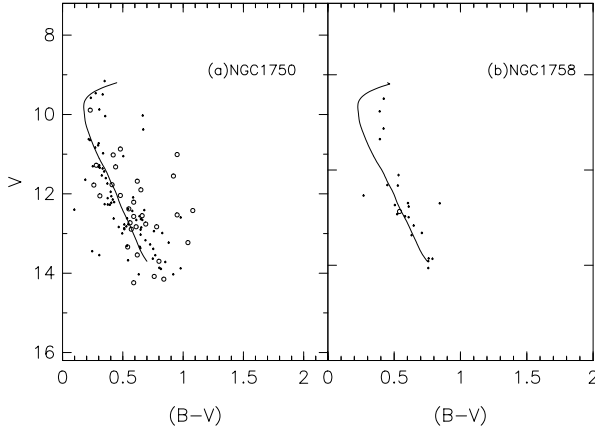
In general, we do not know the cluster distances, so we cannot plot the CMDs on an absolute-magnitude scale. However, most cluster sizes are sufficiently small relative to their distance, so we can assume as usual that all stars belonging to a cluster lie at the same distance. To reduce contamination of field stars as much as possible, we trace the CM diagrams obtained by selecting stars with membership probabilities larger than 0.90, as shown in Fig. 5. It can be found that Fig.5 is much tighter than Fig.4. A careful discussion of the color excess due to dust absorption in front of these two clusters has been presented by GJRT. They found that the interstellar medium is relatively transparent toward the two clusters and the Johnson color excess for both of them is  $\overline{E(B - V)} = (0.34 \pm 0.07)$  mag,



**Fig. 4.** The CM diagrams of NGC1750 and NGC1758 (see text).

which corresponds to an extinction value of  $\overline{A_V} = (1.1 \pm 0.2)$  mag. Based on these observational properties and the empirical ZAMS (Mermilliod 1981; Schaller et al. 1992), we can derive the distance modular of 8.60mag for NGC1750 and 9.50mag for NGC1758, which correspond to the distances of  $(525 \pm 48 \text{ pc})$  for NGC1750 and  $(794 \pm 73 \text{ pc})$  for NGC1758 with core radii of 2.6 pc and 0.5 pc respectively (TZSS).

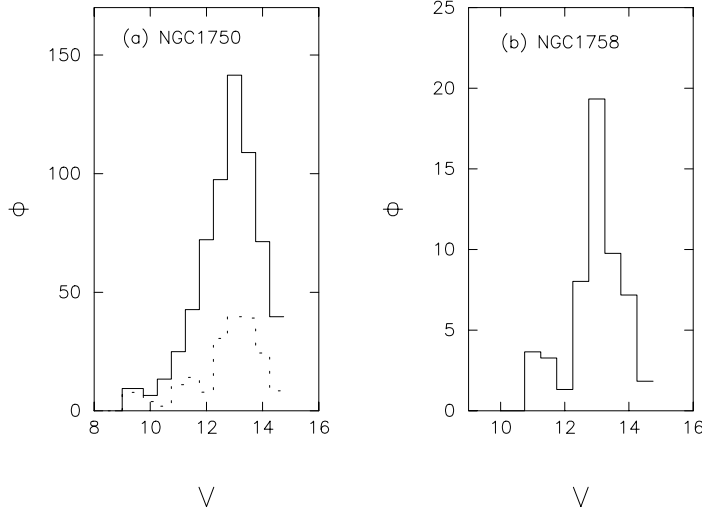
The age distribution of open clusters plays an important role in many astrophysical researches, which can be used to estimate the lower limit for the age of the Galactic disk (Grenon, 1989), investigate the formation and evolution, especially the star formation history of our disk, as well as its dynamics (Janes & Phelps, 1994; Shu et al 1996). There are various methods to estimate ages of open clusters, which can lead to a significant scatter of the results for individual cluster. This is because of the differences among isochrone fitting, conversion from theoretical to observed stellar parameters, and so on. The most popular method adopted up to today is the fitting of theoretical isochrones to the observed CM diagram. The age determination of NGC1750 and NGC1758 in the present study is relatively difficult because of the relatively small number of photographic plates



**Fig. 5.** The CM diagrams of NGC1750 and NGC1758, which are resulted from stars with membership probabilities  $P \geq 0.90$ , the solid lines denote ischrone fitting (see text). (a) NGC1750; (b) NGC1758

and some bright stars over-saturated, i.e., it is difficult to determine the turn-off points of these two clusters. Another reason is the relatively poor precision of the photographic photometries. Here, the same as GJTR did, we assume that the brightest stars on the main sequences of Fig. 5 denote the turn-off points of these two clusters, which are to be compared to the isochrones. After comparing the observed color-magnitude diagrams with those of theoretical results given by Schaller et al. (1992) for solar metallicity, we get the estimated ages of  $1.5 \times 10^8$ yr for NGC1750 and  $6.3 \times 10^8$ yr for NGC1758, which are shown in Fig. 5

The lifetimes of main sequence stars as a function of their absolute visual magnitudes  $M_V$  are also presented by Meynet et al (1993). The brightest star, for NGC1750, which is assumed to be on the MS, is at  $V = 8.42$  mag, which corresponds to an age of about  $4.1 \times 10^8$ yr. Similarly, the fact that the brightest star on the MS for NGC1758 has  $V = 10.77$  mag leads to its age of  $7.9 \times 10^8$ yr. According to the relation among stellar mass, lifetime and its  $M_V$  given by Miller & Scalo (1979), we can also obtain  $1.6 \times 10^8$ yr and  $7.8 \times 10^8$ yr for the ages of



**Fig. 6.** The observed LFs. (a) NGC1750, where the dots line denote the LF of the core region; (b) NGC1758.

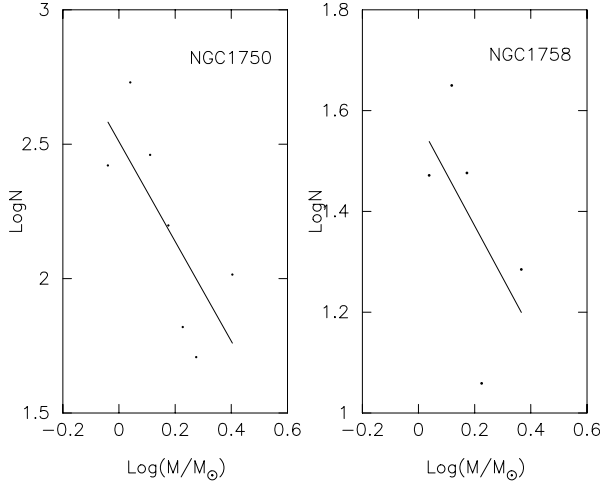
NGC1750 and NGC1758, respectively. If the relation between  $M_V$  and lifetime is chosen as that presented by Mermilliod (1981), the ages of  $3.6 \times 10^8 \text{ yr}$  and  $9.2 \times 10^8 \text{ yr}$  for NGC1750 and NGC1758 are inferred respectively. All adopted relations in present work are the average results. The main reasons for these different results are: (1) the different evolution tracks for stars resulted from different stars evolutionary model; (2) the different weight of metalliaities. Combining all these results, we get the average age estimations for NGC1750 and NGC1758 should be  $(2.2 \pm 1.0) \times 10^8 \text{ yr}$  and  $(7.8 \pm 1.2) \times 10^8 \text{ yr}$ , respectively.

### 3.2. Luminosity functions and mass functions

It is important to study luminosity functions (LFs) and mass functions (MFs) of individual open clusters because they can provide information about both the initial mass function (IMF) and cluster dynamical evolution. Conceptually, the simplest estimation of a cluster luminosity function is to count stars within the cluster. In order to reduce the contamination of field stars, the sum of stars' membership probabilities in different magnitude bins is one of the best to determine the luminosity functions  $\Phi(V)$  for individual clusters, i.e.,

$$\Phi(V) = \frac{\sum P(i)}{\Delta V}, \quad (2)$$

where  $P_c(i)$  is the membership probability of star  $i$  within the magnitude range of  $V$  to  $V + \Delta V$ . Table 5 and Fig. 6 show the LFs for NGC1750 and NGC1758,



**Fig. 7.** The observed present-day mass functions for NGC1750 and NGC1758

respectively. One can see that there exists a peak for either clusters' LFs, which to some extent reflects the complete magnitudes of the samples. The LF of the core region, which is within the center of  $2.6pc$ , of NGC1750 is also given in Fig. 6 as a dotted line. We did not do the same thing for the NGC1758 because of its small number of member stars within the core. It is clear that the profiles of luminosity functions in the central and whole observed region for NGC1750 are quite similar, i.e., there does not exist obvious mass segregation for NGC1750. The fact that the dynamical relaxation has not undergone thoroughly is consistent with its relatively young age (see last subsection). Combining the observed luminosity functions derived above and the mass-luminosity relations for main sequence stars given by Miller and Scalo (1979), we can infer the present-day mass functions of these two clusters, and the results are listed in Table 6 and also shown in Fig. 7 respectively. Here the average masses in individual mass bins are weighted by membership probability, and  $\Sigma P$  is summed over the stars in each bin as we did for their LFs, i.e.

$$\Psi(M/M_{\odot}) = \frac{\Sigma P_i}{\Delta(M/M_{\odot})_i}, \quad (3)$$

with  $(M/M_{\odot})_i = \frac{\Sigma P_i (M_i/M_{\odot})}{\Sigma P_i}$ , here  $M_i$  is the star mass with membership probabilities  $P_i$  in the mass bin  $\Delta(M/M_{\odot})$ .

The slopes of the present-day mass functions of the two clusters are obtained by the least-squares linear regression. The results are shown by means of Log-Log plots in Figure 7. The slopes are  $(-1.85 \pm 0.19)$  and  $(-1.18 \pm 0.33)$  with the corre-

**Table 5. The luminosity functions of NGC1750 and NGC1758**

NGC1750		NGC1758	
V	$\Sigma P$	$M_V$	$\Sigma P$
< 9.5	4.69	< 11.0	1.83
9.5 – 10.0	3.26	11.0 – 11.5	1.62
10.0 – 10.5	6.67	11.5 – 12.0	0.66
10.5 – 11.0	12.48	12.0 – 12.5	4.01
11.0 – 11.5	21.34	12.5 – 13.0	9.67
11.5 – 12.0	36.07	13.0 – 13.5	4.88
12.0 – 12.5	48.75	13.5 – 14.0	3.59
12.5 – 13.0	70.76	> 14.0	0.92
13.0 – 13.5	54.42		
13.5 – 14.0	35.65		
> 14.0	19.85		

lation coefficients of 0.83 and 0.66 for NGC1750 and NGC1758 respectively. Both clusters show the negative slopes. This also implies that they have not suffered the dynamical relaxation, which is consistent with the previous results.

Furthermore, based on the M/L relation given by Miller & Scalo (1979), the observed masses in the cluster region can be estimated to be about  $390 M_\odot$  and  $40M_\odot$  for NGC1750 and NGC1758, respectively. Here, binary stars are not considered, so these results are probably underestimated.

### 3.3. The kinematics

We might hope that direct studies of the kinematics of stars in NGC1750 and NGC1758 would reveal the effect of mass and space segregation. A reliable method for studying the kinematics of open clusters is based on proper motions of the member stars, which are comparatively easy to be obtained. In our sample, the average accuracy of proper motions is  $0.67 \text{ mas yr}^{-1} (\text{TZSS})$ , which corresponds

**Table 6. The mass functions of NGC1750 and NGC1758**

NGC1750			NGC1758		
bin	$\overline{\text{mass}}$	$\Sigma P$	bin	$\overline{\text{mass}}$	$\Sigma P$
( $M/M_{\odot}$ )	( $M/M_{\odot}$ )		( $M/M_{\odot}$ )	( $M/M_{\odot}$ )	
< 1.0	0.91	79.03	< 1.2	1.09	6.52
1.0 – 1.2	1.10	107.48	1.2 – 1.4	1.31	8.93
1.2 – 1.4	1.29	57.82	1.4 – 1.6	1.49	5.99
1.4 – 1.6	1.50	31.56	1.6 – 1.8	1.68	2.29
1.6 – 1.8	1.69	13.21	> 1.8	2.32	3.47
1.8 – 2.0	1.88	10.21			
> 2.0	2.54	15.53			

to  $1.7 \text{ km s}^{-1}$  for the distance of NGC1750 and  $2.5 \text{ km s}^{-1}$  for the distance of NGC1758. Considering the stars with membership probabilities greater than 0.70, we estimate the intrinsic proper motion dispersions based on all the stars in the sample using the method outlined by Sagar & Bhatt (1988). The dependences of the intrinsic velocity dispersions on stellar masses and distances from the cluster centers are listed in Table 7 and Table 8 for NGC1750 and NGC1758 respectively, where the radial distances of each star is measured from the centers of the two clusters determined by TZSS, and N denotes the star number we used. One can see in Table 7 that there is no statistically significant radial dependence of the intrinsic proper motion dispersion  $\sigma_{\mu}$ . The values of  $\sigma_{\mu}$  for different radial shells are almost the same within their uncertainties. It can also be seen from Table 7 that the intrinsic velocity dispersions  $\sigma_{\mu}$  of different mass groups are almost the same. This means that the present data provide little evidences of mass segregations in these two young open clusters, which is consistent with the results we obtained above. Even so, we can find from Table 7 that in the core region of NGC1750 ( $r < 20 \text{ arcmin}$ ), the intrinsic velocity dispersions of the stars with larger mass are smaller than the intrinsic velocities of the stars with smaller mass, there exists some degree of both space and velocity mass segregation in the center region of NGC1750, where the dynamical relaxation is easy to undergo. But it is not clear for NGC1758 due to its small number of member stars.



**Table 7. Dependence of intrinsic dispersion in proper motion on stellar mass and radial distance for NGC1750**

Radius (arcmin)	V (mag)	Mass (M/M <sub>⊙</sub> )	$\sigma_\mu$ ("/100yr)	N
	< 11.0	1.76 – 3.77	$0.141 \pm 0.019$	28
	11.0 – 12.0	1.34 – 1.76	$0.175 \pm 0.016$	59
	12.0 – 12.5	1.19 – 1.34	$0.181 \pm 0.019$	47
	12.5 – 13.0	1.05 – 1.19	$0.179 \pm 0.015$	68
	13.0 – 13.5	0.98 – 1.05	$0.189 \pm 0.020$	52
	> 13.5	0.73 – 1.05	$0.132 \pm 0.012$	57
< 10			$0.149 \pm 0.015$	48
10 – 20			$0.166 \pm 0.015$	62
20 – 30			$0.190 \pm 0.014$	91
30 – 40			$0.189 \pm 0.016$	70
> 40			$0.172 \pm 0.019$	40
< 10	< 12.5	1.19 – 3.77	$0.109 \pm 0.015$	25
10 – 20	< 12.5	1.19 – 3.77	$0.138 \pm 0.019$	25
20 – 30	< 12.5	1.19 – 3.77	$0.189 \pm 0.021$	39
30 – 40	< 12.5	1.19 – 3.77	$0.197 \pm 0.025$	30
> 40	< 12.5	1.19 – 3.77	$0.158 \pm 0.029$	15
< 10	> 12.5	0.73 – 1.19	$0.168 \pm 0.026$	23
10 – 20	> 12.5	0.73 – 1.19	$0.180 \pm 0.021$	37
20 – 30	> 12.5	0.73 – 1.19	$0.188 \pm 0.018$	52
30 – 40	> 12.5	0.73 – 1.19	$0.180 \pm 0.020$	40
> 40	> 12.5	0.73 – 1.19	$0.165 \pm 0.020$	25

To gain information about the isotropy or anisotropy of the velocity distribution, the radial and tangential components  $\sigma_{\mu r}$ ,  $\sigma_{\mu t}$  of the intrinsic dispersions of proper motions as a function radius are calculated and listed in Table 9, where the

**Table 8. Dependence of intrinsic dispersion in proper motion on stellar mass and radial distance for NGC1758**

Radius (arcmin)	V (mag)	Mass (M/M <sub>⊙</sub> )	$\sigma_\mu$ ("/100yr)	N
<hr/>				
< 12.8	1.41 – 2.61	0.123 ± 0.025	12	
> 12.8	1.02 – 1.38	0.110 ± 0.024	11	
<hr/>				
< 2		0.126 ± 0.028	11	
> 2		0.113 ± 0.023	12	
<hr/>				

units of radial distance  $r$  and of proper motion dispersions  $\sigma_\mu$  have been converted into pc and  $\text{kms}^{-1}$  respectively. The computation has been made for stars in the NGC1750 and NGC1758 regions with membership probabilities higher than 0.7. It can be found for both clusters that the ratios  $\sigma_{\mu r}/\sigma_{\mu t}$  fluctuate around unity, which implies the absence of any significant evidence of velocity anisotropy. On the other hand, because the number of member stars is small, we can not get any certainly statistical results for NGC1758, but at least we can conclude that except the center region of NGC1750, there is no obvious velocity mass segregation or spatial mass segregation among the member stars of NGC1750, which suggests that this young open cluster has not reached energy equipartition.

#### 4. Conclusion

In the present paper, based on the proper motions, photometries and membership probabilities of individual stars in the region of NGC1750 (TZSS, GJTR), we investigate basic astrophysical properties for two dynamically independent open clusters, NGC1750 and NGC1758. After detailed discussions on the photometric data and membership probabilities, the analysis samples with star number of 311 and 23 for NGC1750 and NGC1758 are constructed respectively. Comparing ZAMS (Mermilliod 1981; Schaller et al. 1992), we obtain the distances for these two clusters of  $(525 \pm 48)$  pc for NGC1750 and  $(794 \pm 73)$  pc for NGC1758 with their extinction being considered. Furthermore, many methods for the age de-

**Table 9. Dependence of radial and tangential intrinsic dispersion in proper motion on stellar mass and radius**

Cluster	radius (pc)	$\sigma_{\mu r}$ (kms <sup>-1</sup> )	$\sigma_{\mu t}$ (kms <sup>-1</sup> )	$\sigma_{\mu r}/\sigma_{\mu t}$	$N$
NGC1750	< 1.54	$5.86 \pm 0.77$	$6.10 \pm 0.69$	$0.96 \pm 1.47$	48
	1.54 – 3.07	$5.22 \pm 0.55$	$4.08 \pm 0.48$	$1.28 \pm 1.72$	62
	3.07 – 4.61	$5.18 \pm 0.42$	$5.90 \pm 0.50$	$0.88 \pm 1.20$	91
	4.61 – 6.15	$5.40 \pm 0.55$	$5.22 \pm 0.55$	$1.03 \pm 1.20$	70
	> 6.15	$4.85 \pm 0.91$	$6.23 \pm 0.91$	$0.77 \pm 1.26$	40
NGC1758	< 0.46	$6.00 \pm 1.50$	$5.77 \pm 1.72$	$1.04 \pm 1.36$	11
	> 0.46	$1.74 \pm 0.97$	$3.16 \pm 1.93$	$0.55 \pm 0.94$	12

termination are adopted to estimate the average ages of  $(2.2 \pm 0.6) \times 10^8$ yr and  $(7.8 \pm 1.6) \times 10^8$ yr with the observed masses  $390 M_{\odot}$  and  $40 M_{\odot}$  for NGC1750 and NGC1758 respectively.

According to the results of membership determination, luminosity functions and mass functions are given at the same time. It can be concluded that there exist no significant mass segregation effects for both clusters, which is consistent with the fact that their dynamical relaxation have not undergone thoroughly.

Finally, the velocity distributions of member stars for these two clusters are also discussed. It is found that both clusters seem to be isotropy in velocity space. Moreover, it is worth nothing that our statistical results could not be enough certain for NGC1758 because of its small number of member stars observed.

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